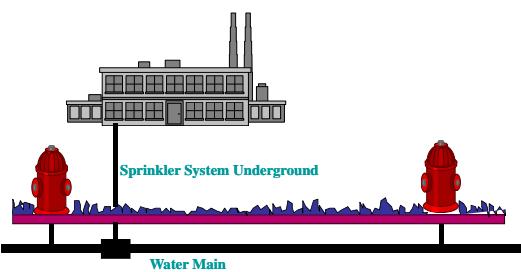




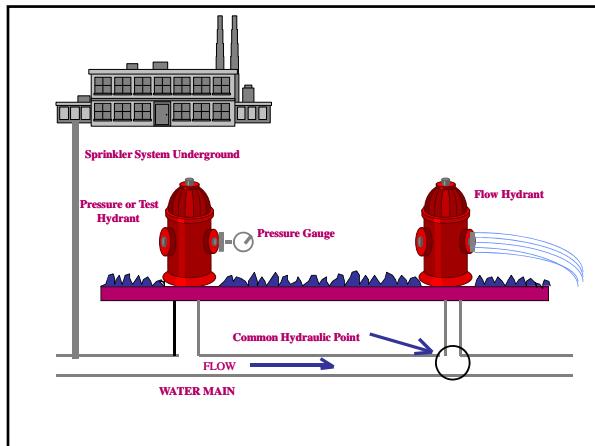
Ignatius Kapalczyński

EVALUATING WATER SUPPLIES



INFORMATION REQUIRED

- Static Pressure
- Residual Pressure
- GPM
 - 1. Pitot Reading
 - 2. Hydrant Coefficient
 - 3. Butt Opening



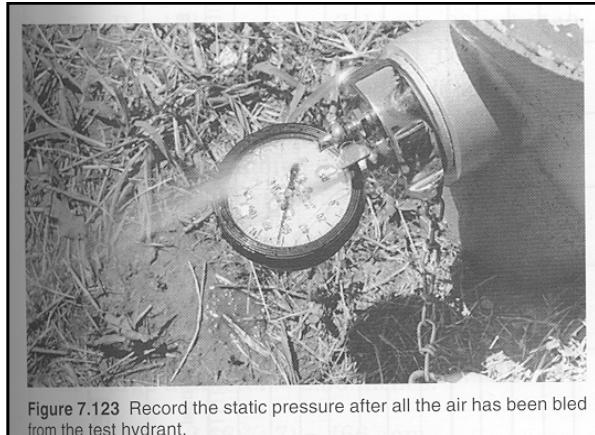


Figure 7.123 Record the static pressure after all the air has been bled from the test hydrant.

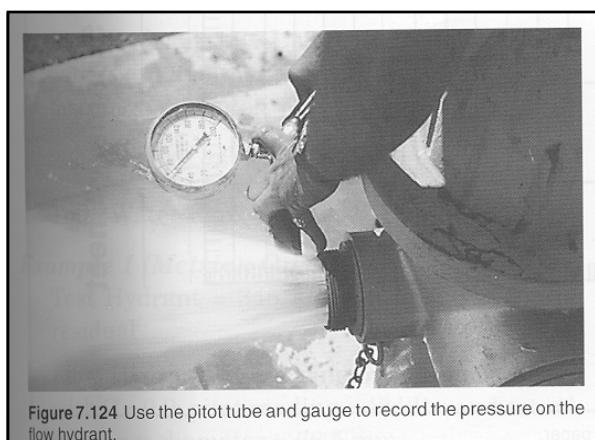
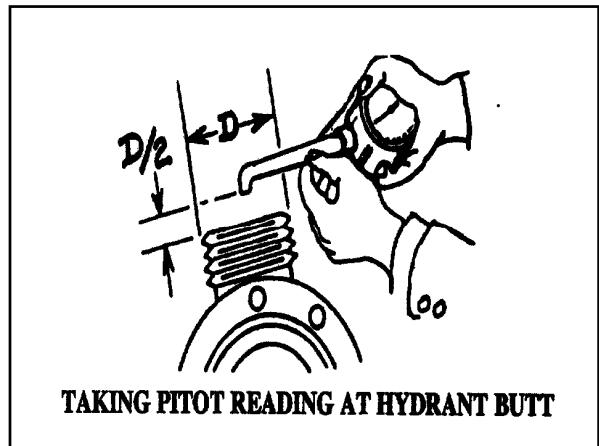
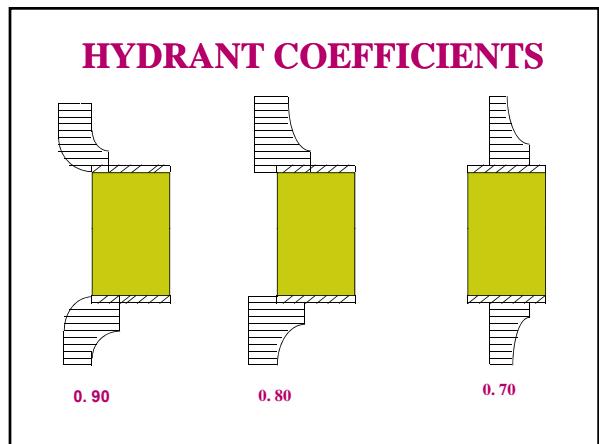
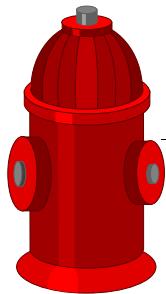


Figure 7.124 Use the pitot tube and gauge to record the pressure on the flow hydrant.









EXAMPLE PROBLEM

- Static Pressure 80 psi
- Residual Pressure 47 psi
- Pitot Reading 14
- Hydrant Coefficient 90
- Butt Opening 2.5 inches
- GPM = ?

$$\underline{Q = \text{GPM}}$$

- $Q = 29.83 \times (\text{butt opening})^2 \times \text{square root of pressure obtained (pitot press.)} \times \text{hydrant coefficient}$

GPM FORMULA

Hydrant Outlet	Pitot Reading	Hydrant Opening Coefficient
-------------------	------------------	-----------------------------------

$$29.83 \times (2.5)^2 \times \sqrt{14} \times .90$$

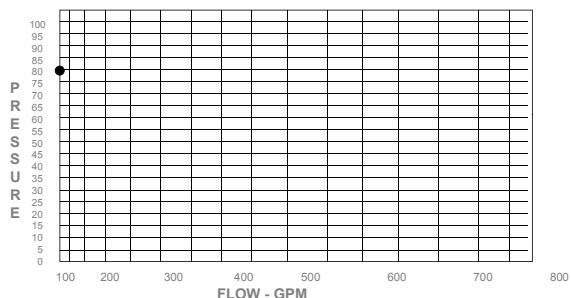
OR

$$29.83 \times 6.25 \times 3.74 \times .90$$

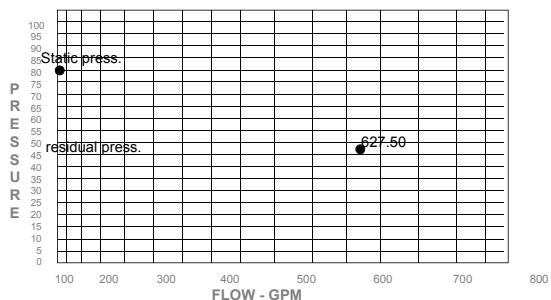
OR

$$\text{GPM} = 627.50$$

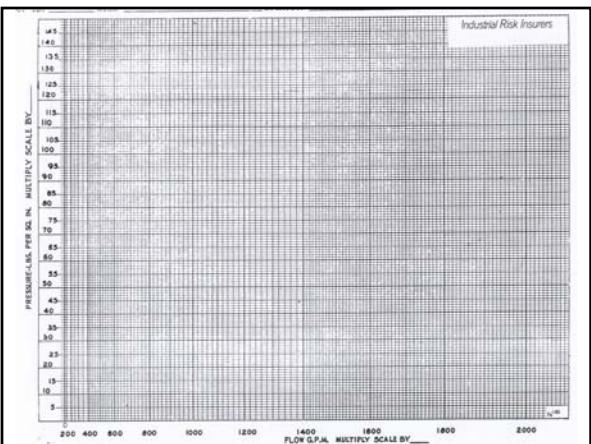
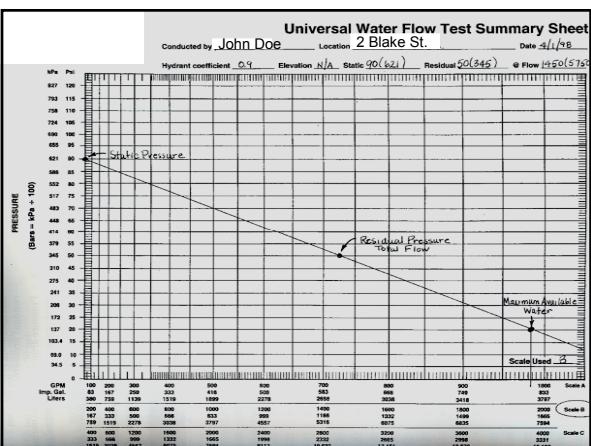
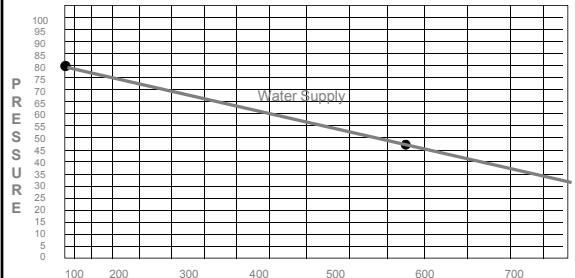
FLOW TEST SUMMARY SHEET

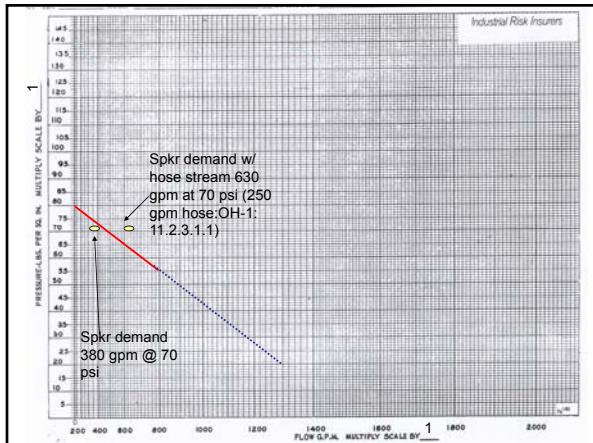
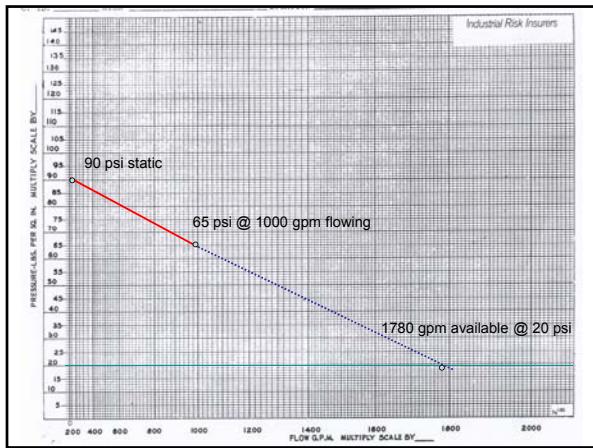


FLOW TEST SUMMARY SHEET



FLOW TEST SUMMARY SHEET





Pumps

- Increase Pressure NOT Volume
 - Increases the velocity of the water
- Does NOT “make water”
 - NO H₂ and O₂ inlets





Know what your Water Supply is at Plan Review

- Were pressure and flow tests taken from correct hydrants?
- Static Pressure?
- Residual pressure?
- GPM?
- Duration

Water Flow Testing



- Pitot tube
- Gauge

Reference Hydrant



Hydrant Cap Gauge



Flow Hydrant

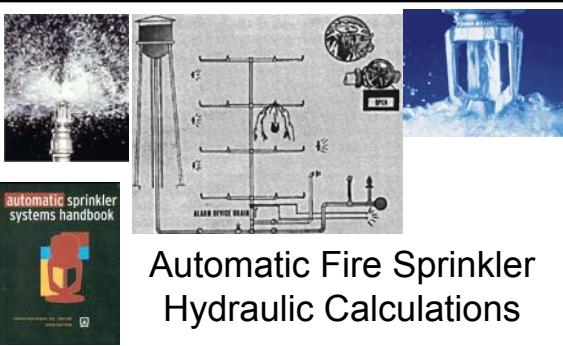


More Flow – More Info

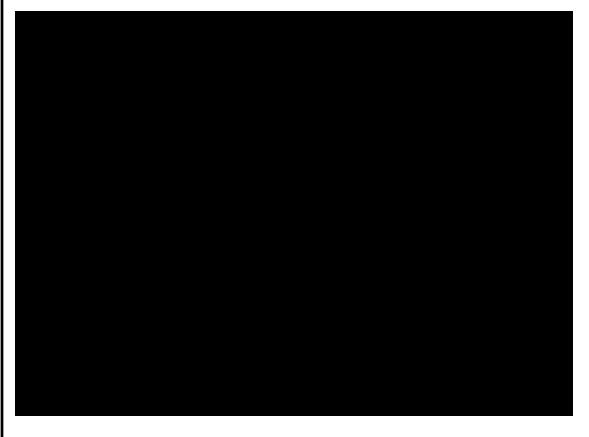


Keep it simple?





February 2011 Career Development
Department of Public Safety
Office of the State Fire Marshal



Objectives

- Determine the adequacy of the sprinkler design using NFPA 13 2002 edition.
- Fundamentals of Hydraulics
- Understanding How and Why Hydraulic Calculations are done
- Common errors
- Sample problem
- Layout and Spacing will NOT be discussed, a different topic

History of Sprinklers

- 1852 Perforated Pipe in Textile Mills – non automatic
- 1874 Henry Parmalee Automatic Sprinklers Into Piano Factory New Haven CT
- 1881 Fredrick Grinnell improved Parmalee's design, patented sprinkler that bears his name.
- 1890 Glass Bulb AS Head developed.

Purpose & Function of Automatic Sprinklers

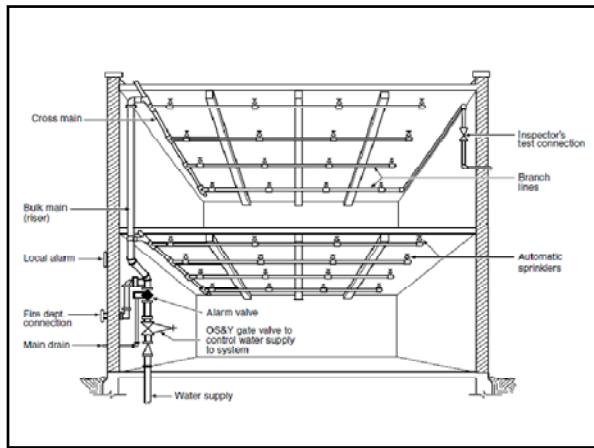
- *Fire generates heat release BTU's*
- *Water absorbs energy in BTU's*
- *When heat release rate from fire equals heat absorption rate from water, fire is controlled*

Objective of Sprinklers

- *Deliver water to achieve goal*
- *Sufficient volume*
- *Most efficient size*
- *With energy for dispersal and plume penetration*
- *Throughout area covered*

Sprinklers

- *System of pipes*
- *Heat activated devices*
- *With deflectors to create patterns of droplets*
 - Small enough to absorb lots of heat
 - Large enough to overcome flame plumes
 - Fast enough to penetrate



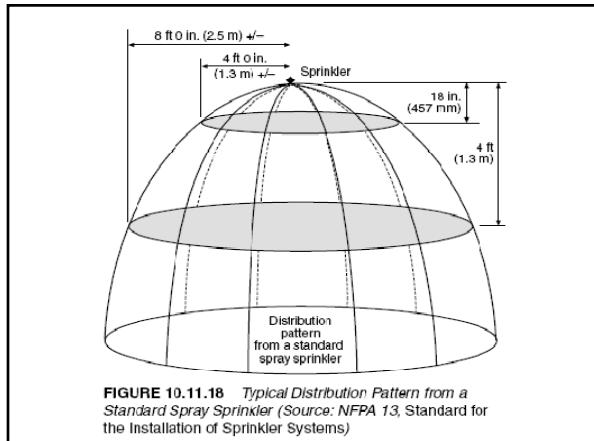


FIGURE 10.11.18 Typical Distribution Pattern from a Standard Spray Sprinkler (Source: NFPA 13, Standard for the Installation of Sprinkler Systems)

A Quick Review

- Wet Pipe
 - Dry Pipe
 - Deluge
 - Pre Action
- Tree system
 - Loop system
 - Grid system

Fundamentals of Hydraulics

- Water
 - Volume
 - Mass
 - Pressure

Fundamentals of Hydraulics

- Pressure
 - Static
 - Residual
 - Energy

Fundamentals of Hydraulics

- Gravity
 - Elevation
 - 0.433 lb/ft

Fundamentals of Hydraulics

- Friction Loss
 - Pipe Size
 - Pipe Material

Install Pipes and Add Water
IS
Overly Simplistic



Owners Certificate (4.3)

- Owner or Authorized Agent

- Prior to the layout and design of the system
 - Intended use of the building including material within the building and maximum height of any storage
 - A preliminary plan of the building along with the design concept necessary to perform the layout and detail of the sprinkler system.
 - Any special knowledge of the water supply including known environmental conditions (MIC)

What's Burning?

- *Material or Commodity*

- Class I
- Class 2
- Class 3
- Class 4
- Plastics, Group A, B, C
- Flammable Liquids

What's Burning?

- *Arrangement*

- Packaging
- Encapsulation
- Raw material
- Form
 - Solid
 - Dust
 - Mist
 - Liquid

What's Burning?

- *Height*
 - < 12 feet
 - Piles
 - Racks

What's Burning?

- *Quantity*
 - Light
 - Ordinary 1 or 2
 - Extra Hazard 1 or 2
 - Special

Design Area

- *Area of Operation – Function of Hazard Class*
- *Density – Function of Commodity & Arrangement*
- *Spacing*
- *Maximum System Area*
- *Number of Branch Lines*
- *Number of Sprinklers per Branch Line*

What is K??

- Discharge coefficient (theoretical) of the sprinkler that determines how much water can flow from it.
 - Sprinklers are identified by it rather than an orifice size. i.e $k=5.6$ not a $1/2"$ orifice sprinkler.
 - Have ranges for various orifice table 6.3.2.1
 - K ranges 1.4 to 28 (and larger special)

Typical Ranges

Nominal K-Factor gpm/(psi) ^{1/2}	K-Factor Range gpm/(psi) ^{1/2}	K-Factor Range dm ³ /min/(kPa) ^{1/2}	Percent of Normal K-5.6 Discharge	Thread Type
1.4	1.3–1.5	1.9–2.2	25	½ in. NPT
1.9	1.8–2.0	2.6–2.9	33.3	½ in. NPT
2.8	2.6–2.9	3.8–4.2	50	½ in. NPT
4.2	4.0–4.4	5.9–6.4	75	½ in. NPT
5.6	5.3–5.8	7.8–8.4	100	½ in. NPT
8.0	7.4–8.2	10.7–11.8	140	¾ in. NPT
11.2	11.0–11.5	15.9–16.6	200	¾ in. NPT
14.0	13.5–14.5	19.5–20.9	250	¾ in. NPT
16.6	16.0–17.6	22.1–25.1	300	¾ in. NPT
19.6	18.6–20.6	27.2–30.1	350	1 in. NPT
22.4	21.3–23.5	31.1–34.3	400	1 in. NPT
25.2	23.9–26.5	34.9–38.7	450	1 in. NPT
28.0	26.6–29.4	38.9–43.0	500	1 in. NPT

Source: NFPA 13, Standard for the Installation of Sprinkler Systems

Derivation of k

- Simplification of
 - $\Omega = (29\ 83) \times (\Omega)$

Simplification of

$$Q = \underbrace{(29.83) \times (C_d) \times (d^2) \times (P)^{1/2}}_k$$

Velocity pressure

The diagram shows a cylindrical nozzle of diameter d with a pitot tube at the exit. The nozzle is inclined at an angle. The pitot tube measures total pressure P_n . The exit pressure is P_v . An arrow labeled P_v points from the exit towards the pitot tube. A curved arrow above the nozzle indicates the direction of flow. A bracket labeled $C_d = \text{coef of discharge}$ spans the nozzle exit area.

$Q = k (P)^{1/2}$

$P = \left[\frac{Q}{k} \right]^2$

$P_n \gg P_v$ and the assumption is that at the point of discharge all of P_n is converted to P_v

$Q = \text{Discharge (gpm)}$
 $k = \text{Constant of discharge (gpm/min/psi)}$
 $P = \text{Nozzle (pitot) pressure (psi)}$

Design Approaches

- Occupancy Hazard Fire Control (Ch 11.2)
 - Most Common
 - Used Design Densities (i.e. 0.15 gpm/ft²)
- Special Occupancy Requirements (Ch 13)
 - Requirements from other NFPA standards
 - Flammable & combustible Liquids; Solvent extraction plants; Laboratory using chemicals; etc.
- Storage Design Approach (Ch 12)
 - Old NFPA 231, 231C
 - Commodities on racks; Palletized, solid piled, Bin Box or shelf storage of commodities; Rubber tire storage

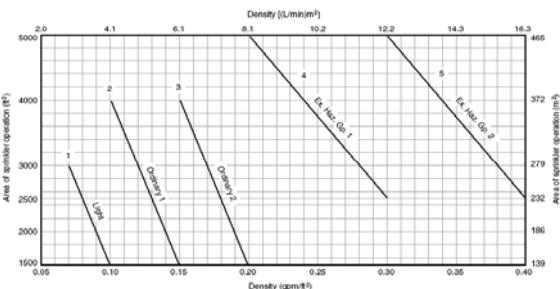
Occupancy Hazard Fire Control

- Pipe Schedule
 - Existing systems
 - New systems or extensions to existing systems where: (light & ord. hazard)
 - New < 5000 ft² or modifications to existing systems sized in accordance with section 14.5, and values in table 11.2.2.1 are met.
 - New > 5000 ft² where table 11.2.2.1 for flow is met and minimum pressure at the highest spkr is 50 psi
 - Additions or modifications to existing high hazard systems only

Occupancy Hazard Fire Control

- Hydraulic Calculation
 - Most common
 - Designers choice, either:
 - Density/area method 11.2.3.3
 - Figure 11.2.3.1.5
 - Chapter 13 for special occupancy hazards
 - Room design method 11.2.3.3
 - Density from 11.2.3.1.5
 - Consideration of most hydraulically remote room(s)
 - Separation requirements

Density / Area Method (14.4.4.1.1.)

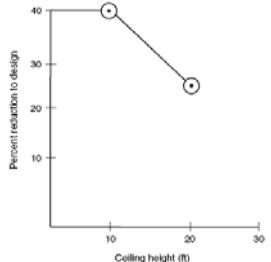


Design to a point, is not required to meet whole curve; i.e.- light 0.10/1500 ft² or 0.07/3000 ft²

Area modifications 11.2.3.2.3

Modify AREA without revising the density.

- QR sprinklers
- Wet system
- Light or Ord. hazard
- 20 ft max ceiling ht
- No unprotected ceiling pockets
- If sloped ceiling use max ceiling height



Area Increases;

- Increase area 30% without revising density
- Multiple adjustments compounded based on the area of operation selected from graph 11.2.3.1.5
 - Sloped ceiling non-storage applications, when slope >1.6 (16.67%) when using spray, EC, or large drop sprinklers. (11.2.3.2.4)
 - Dry & Double interlock pre-action systems (11.2.3.2.5)

Example: Light hazard, dry system, sloped ceiling 1:5, SSP sprinkler

New area = graph 11.2.3.1.5 + 30% + 30%, Graph = 0.10 gpm/ft² over 1500 ft²

New area = 1500 ft² + 30% + 30% = 1500 ft² + 450 ft² + 585 ft² = 2535 ft²

Modified design criteria = 0.10 gpm/ft² over 2535 ft²

Question?

- Ordinary 1 wet sprinkler system, QR sprinklers ceiling height sloped ceiling high point 12 feet (slope > 1:6). What is the design criteria?

Graph 11.2.1.3.5 0.15gpm/ft² over 1500 ft². $Y = \frac{-3X}{2} + 55$

1500 ft² + 30% (slope ceiling) - 37% (QR reduction)

$$1500 \text{ ft}^2 + 450 = 1950 - 721.5 = 1228.5 \text{ ft}^2$$

New design criteria = 0.15 gpm/ft² over 1228.5 ft²

$$Y = \frac{-3(12)}{2} + 55$$

$$Y = 37\%$$

Room Design (14.4.4.1.2/11.2.3.3.)

- Based on the room and space (if any) that is hydraulically most demanding. Corridors are rooms.
 - Popular in highly compartmented spaces.
 - Assumes all of the sprinklers in the room will operate.
 - Rooms to be enclosed by walls with a FRR of that equal to the water supply duration. (11.2.3.1.1)
 - Opening protectives
 - Light haz – non-rated automatic or self closing doors
 - Ord & Extra haz - automatic or self closing doors as required for the FRR
 - Light haz with no opening protectives – calculate the room + 2 in the communicating space at each opening. There are exceptions if 1 head.
 - Use actual room or minimum area of table 11.2.3.1.5
 - Corridor rules for max number of sprinklers in the room is a corridor.

Step by Step Hydraulic Calculations



- TFT in fire room through hose lines,
- down ladders,
- Across yard
- to hydrant

Laws of Conservation

- Mass (Matter)
 - Water in = Water out = Conservation of Mass
 - $Q = Av$ (Q = flow rate, A = Area, v = velocity)
- If pipe size remains constant, water velocity within the system will be constant
- Within the same system, an increase in the pipe diameter will decrease water velocity
- Within the same system, an decrease in the pipe diameter will increase water velocity
- If the pipe size is constant water flowing uphill will travel at the same velocity as water flowing downhill

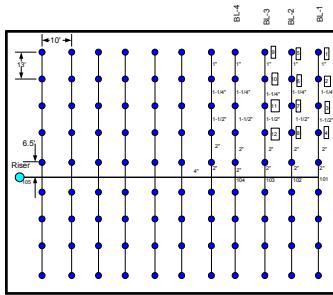
$$Q_1 = A_1 v_1 \quad Q_2 = A_2 v_2 \quad Q_1 = Q_2 \text{ so} \\ A_1 v_1 = A_2 v_2$$

Laws of Conservation

- Energy (Bernoulli's equation)
 - Total energy in a system is the sum of the potential energy and kinetic energy at any point and is constant.
 - $TE = PE_t + KE$
 - A change in either the potential or kinetic energies results in a corresponding change in the other.
 - Energy loss due to friction

Design Area

- Confirm hazard class
- Determine remote area.
- Calculate total sprinklers.
- Calculate most remote sprinkler demand.
- Start crunching.



Confirm Hazard Class

- Most Important
 - Start off on the right foot!
- Not the same as CSFSC
- See NFPA 13 Chap 5
- Additional scenarios listed in the annex.



Show Sprinkler #1

Attach sprinkler to elbow

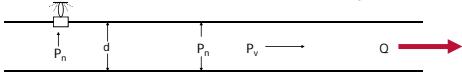
- 1. 10 feet x 13 feet = 130 square feet;
 - 2. K Factor = 5.6
 - 3. Flow = 130 square feet x 0.15 gallons per square foot = 19.5 gallons
 - 4. Review Vitaulic 40.10
 - 5. $Q = K P^{\frac{1}{2}}$ or $P = (Q/K)^2$
 - 6. $P = (19.5 \text{ gallons}/5.6)^2 = 12.1 \text{ psi}$
- 2) Starting Values
 - $Q = 19.5$
 - $P = 12.1$

11) Attach elbow to Pipe #1

Pressure in Pipe

- Normal – P_n - Perpendicular to the walls of the pipe.
- Velocity – P_v Pressure required to move the water through the pipe.
- Total P = normal P+ velocity P $\rightarrow P_t = P_n + P_v$

– As a rule $P_n \gg P_v$ $P_v = \frac{0.001123 Q^2}{d^4}$



Friction Loss in Pipe

- Darcy Weisbach Formula
 - No practical for sprinkler calculations
 - Uses velocity pressures – constantly changing
 - $P = 0.08078 \times V^2 \times F$ (friction factor) /D
- **Assumptions made** experiments performed and equation refined to:
- Hazen Williams Equation
 - Based in empirical data
 - Note: less accurate but easier to use

Hazen Williams Formula

$$P_f = \frac{(4.52)(Q)^{1.85}}{(C)^{1.85} (D)^{4.87}}$$

P_f = the pressure lost to friction in psi/ft of pipe

Q = flow rate in gpm

C = Hazen Williams constant (coefficient of roughness)

D = internal diameter of the pipe in inches

4.52 is a constant (fudge factor)

Some Observations

$$P_f = \frac{(4.52)(Q)^{1.85}}{(C)^{1.85} (D)^{4.87}}$$

Double the pipe diameter (D) reduce friction loss (psi/ft) by a factor of approximately 32

Double the flow (Q) increase friction loss (psi/ft) by a factor of approximately 4

Hazen Williams Constant "C"

- Type of material
 - Relative smoothness
 - New / Old
 - Measure of how well the water will travel through the pipe.
 - Higher the number the easier water will flow

Kind of Pipe	Value of C
Cast iron, unlined - new	100
Cast iron cement lined – new	140
Steel new (wet)	120
Steel new (dry)	100
Plastic or copper	150

NFPA 13 - Table 14.4.4.5

Inside Pipe Diameters "D"

Nom size	Sch 10 ID	Sch 40 ID		
¾"	0.884"	0.824"		
1"	1.097"	1.049"		
1-1/4"	1.442"	1.380"		
1-1/2"	1.682"	1.610"		
2"	2.157"	2.067"		
4"	4.260"	4.026"		

Excerpts from NFPA 13 Table A.6.3.2, use these values unless provided by designer.

Example 100 gpm through 200 ft of 2" steel schedule 40 pipe

$$P_f = \frac{(4.52)(Q)^{1.85}}{(C)^{1.85} (D)^{4.87}}$$

Plugging in the numbers

$$(4.52)(100)^{1.85}$$

$$P_f = \frac{(4.52)(100)^{1.85}}{(120)^{1.85} (2.067)^{4.87}} = 0.09396 \text{ psi/ft}$$

$$P_f = 0.09396 \text{ psi/ft} \times 200 \text{ ft} = 18.79 \text{ psi total for the 200 ft.}$$

Example Friction Loss

- 200 ft of 1" pipe
- Schedule 40 steel

gpm	psi
10	7.2
20	26.03
50	141.78
100	511.10

200 ft of 2" pipe

Schedule 40 steel

gpm	psi
10	0.2654
20	0.957
50	5.213
100	18.79

$$7 \times 4 = 28 \quad 7.2 / 32 = 0.225$$

TABLE 10.11.13 Friction Loss—PSI per Lineal Foot of Pipe, American Standard Weight, Black Steel Pipe

gpm	1 in. (1.049 mm)	1½ in. (1.380 mm)	1¾ in. (1.610 mm)	2 in. (2.067 mm)	2½ in. (2.469 mm)	3 in. (3.068 mm)	3½ in. (3.548 mm)
1	.0005	.0001	.0001	—	—	—	—
2	.0010	.0005	.0002	.0001	—	—	—
3	.0019	.0010	.0005	.0001	.0001	—	—
4	.0029	.0017	.0008	.0002	.0001	—	—
5	.0040	.0026	.0012	.0004	.0002	.0001	—
6	.0140	.0037	.0017	.0005	.0002	.0001	—
7	.0187	.0049	.0023	.0007	.0003	.0001	—
8	.0239	.0063	.0030	.0009	.0004	.0001	.0001
9	.0297	.0078	.0037	.0011	.0005	.0002	.0001
10	.0361	.0095	.0045	.0013	.0006	.0002	.0001
11	.0431	.0113	.0053	.0016	.0007	.0002	.0001
12	.0506	.0133	.0063	.0019	.0008	.0003	.0001
13	.0587	.0154	.0073	.0022	.0009	.0003	.0002
14	.0673	.0177	.0084	.0025	.0010	.0004	.0002
15	.0764	.0201	.0095	.0028	.0012	.0004	.0002
16	.0861	.0226	.0107	.0032	.0013	.0005	.0002

Equivalent Length

- Convert fittings into length of pipe to determine friction loss.
- Table in 13 (14.4.3.1.1) (for schedule 40) or manufacturers data.

Expressed in equivalent feet of pipe; Note C=120

Fitting & Valves	1"	1-1/2"	2"	4"
90 std. ell	2	4	5	10
90 Long turn ell	2	2	3	6
T or cross flow turned 90	5	8	10	20
Gate valve	--	--	1	2

Pipe Fittings & Devices Column

When water flows through fittings, the pressure loss through those fittings must be calculated

Exceptions:

- Fittings connected directly to sprinklers
- Fittings where water flows straight through without changing direction
- Pressure Losses must be included for devices such as Check Valves and Control Valves

Equivalent Length Modifiers

- Other than sch 40 Ex. 2" sch 10 steel

$$\text{Factor} = \left(\frac{\text{Actual inside diameter}}{\text{Sch 40 steel pipe ID}} \right)^{4.87} = \left(\frac{2.157}{2.067} \right)^{4.87} = 1.23$$

Equivalent Length Modifiers

- $C \neq 120$ (not black iron)

Value of C	100	130	150
Mult. factor	0.713	1.16	1.51

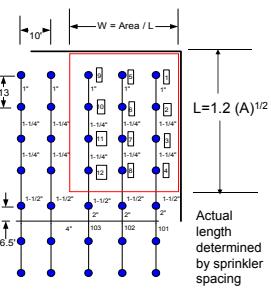
NFPA 13 Table 14.4.3.2

Example Using Multipliers

- From table 14.4.3.1.1 a 2" 90 degree standard elbow has an equivalent length of 5 feet of pipe.
 - If we are using schedule 10 pipe, then the new equivalent length is $(1.23)(5) = 6.15$ feet.
 - Now say system is dry then $C = 100$ and the multiplier is 0.713; the new equivalent length is $(5)(0.713) = 3.565$ ft.
- 2" steel sch 10, 90 degree std elbow, dry system; $(5)(1.23)(0.713) = 4.38$ feet equivalent

Remote Area Configuration

- Rectangular shape with longer side equal to $1.2 \times$ Square Root A ie $(A)^{1/2}$
 - Example light hazard 0.10 over 1500 ft²
 - $L = 1.2(A)^{1/2} =$
 - $1.2(1500)^{1/2} = 46.5$ ft.
- Width = Area / L
 - $W = 1500 / 46.5 = 32.25'$
 - $46.5 \times 32.25 = 1500$



12) Pipe # 1

- 1) Material
 - 1. Steel
 - 2. Copper
 - 3. Plastic
- 2) Length
 - 1. Fittings
 - 2. Equivalent Length
- 3) Diameter – Actual
- 4) Roughness – (Coarseness, ie sandpaper)
 - 1. C = 120 Steel
 - 2. C = 100 Dry pipe (non galvanized)
 - 3. C = 150 Plastic
 - 4. C = 140 Underground cement lined steel
- 2) Pipe # 1
 - 1. Q = 19.5
 - 2. C = 120
 - 3. D = 1.049
 - 4. L = 2
 - 5. Fitting = 0
 - 6. Elevation = 0

14) Step #1

S.	No.	P _{total}	Q _{actual}	Q _{desir}	C _{factor}	Diameter	Length	F _{finge}	E _{vol}	L _{lose}	P _{friction Loss} x E _{vol}	P _{friction Loss} x E _{vol}	L _{vertical}	L _{horizontal} x 0.02	P _{friction Loss} x P _{loss}	P _{friction Loss} x P _{loss}
1	1-2	14.25														
2	2-3															
3	3-4															
4	4-5															
5	5-6															

S _{no}	N _{od}	P _{ini} al	Q _{ad} ded	Q _{ref} al	C _{Fact} or	D _{name} ter	L _{epi} gh	F _{fl} rags	E _{QV} L	L _{To} total	P _{friction} Loss	P _{friction} Loss x E _{QV,L}	L _{Vertical}	P _{friction} Loss + P _{elevation} + P _{Total}
1	1 - 2	12.13	19.5	19.5										
2	2 - 3													
3	3 - 4													
4	4 - 5													
5	5 - 6													

S _{no}	N _{od}	P _{ini} al	Q _{ad} ded	Q _{ref} al	C _{Fact} or	D _{name} ter	L _{epi} gh	F _{fl} rags	E _{QV} L	L _{To} total	P _{friction} Loss	P _{friction} Loss x E _{QV,L}	L _{Vertical}	P _{friction} Loss + P _{elevation} + P _{Total}
1	1 - 2	12.13	19.5	19.5										
2	2 - 3													
3	3 - 4													
4	4 - 5													
5	5 - 6													

S _{no}	N _{od}	P _{ini} al	Q _{ad} ded	Q _{ref} al	C _{Fact} or	D _{name} ter	L _{epi} gh	F _{fl} rags	E _{QV} L	L _{To} total	P _{friction} Loss	P _{friction} Loss x E _{QV,L}	L _{Vertical}	P _{friction} Loss + P _{elevation} + P _{Total}
1	1 - 2	12.13	19.5	19.5	19.5									
2	2 - 3													
3	3 - 4													
4	4 - 5													
5	5 - 6													

S _{no}	N _{od}	P _{ini} al	Q _{ad} ded	Q _{ref} al	C _{fact} or	D _{flame} ter	L _{epi} gh	F _{fl} rags	E _{QV} L	L _{To} ter	P _{friction} Loss	P _{friction} Loss x E _{QV,L}	L _{Vertical}	P _{friction} Loss + P _{elevation} + P _{Total}
1	1 - 2	12.13	19.5	19.5	120	1.049								
2	2 - 3													
3	3 - 4													
4	4 - 5													
5	5 - 6													

S _{no}	N _{od}	P _{ini} al	Q _{ad} ded	Q _{ref} al	C _{fact} or	D _{flame} ter	L _{epi} gh	F _{fl} rags	E _{QV} L	L _{To} ter	P _{friction} Loss	P _{friction} Loss x E _{QV,L}	L _{Vertical}	P _{friction} Loss + P _{elevation} + P _{Total}
1	1 - 2	12.13	19.5	19.5	120	1.049	2							
2	2 - 3													
3	3 - 4													
4	4 - 5													
5	5 - 6													

S _{no}	N _{od}	P _{ini} al	Q _{ad} ded	Q _{ref} al	C _{fact} or	D _{flame} ter	L _{epi} gh	F _{fl} rags	E _{QV} L	L _{To} ter	P _{friction} Loss	P _{friction} Loss x E _{QV,L}	L _{Vertical}	P _{friction} Loss + P _{elevation} + P _{Total}
1	1 - 2	12.13	19.5	19.5	120	1.049	2							
2	2 - 3													
3	3 - 4													
4	4 - 5													
5	5 - 6													

S _{no}	N _{od}	P _{ini} al	Q _{ad} ded	Q _{ref} al	C _{fact} or	D _{flame} ter	L _{epi} gh	F _{fl} rps	E _{QV} L	L _{To} total	P _{friction} Loss	L _{Vertical}	P _{friction} Loss x E _{QV,L}	L _{Vertical}	P _{friction} Loss + P _{elevation} + P _{Total}
1	1 - 2	12.13	19.5	19.5	120	1.049	2			2	0.124				
2	2 - 3														
3	3 - 4														
4	4 - 5														
5	5 - 6														

S _{no}	N _{od}	P _{ini} al	Q _{ad} ded	Q _{ref} al	C _{fact} or	D _{flame} ter	L _{epi} gh	F _{fl} rps	E _{QV} L	L _{To} total	P _{friction} Loss	L _{Vertical}	P _{friction} Loss x E _{QV,L}	L _{Vertical}	P _{friction} Loss + P _{elevation} + P _{Total}
1	1 - 2	12.13	19.5	19.5	120	1.049	2			2	0.124				
2	2 - 3														
3	3 - 4														
4	4 - 5														
5	5 - 6														

S _{no}	N _{od}	P _{ini} al	Q _{ad} ded	Q _{ref} al	C _{fact} or	D _{flame} ter	L _{epi} gh	F _{fl} rps	E _{QV} L	L _{To} total	P _{friction} Loss	L _{Vertical}	P _{friction} Loss x E _{QV,L}	L _{Vertical}	P _{friction} Loss + P _{elevation} + P _{Total}
1	1 - 2	12.13	19.5	19.5	120	1.049	2			2	0.124				
2	2 - 3														
3	3 - 4														
4	4 - 5														
5	5 - 6														

HINT

- Write flows & pressures on drawings

Attach Pipe to Tee

- 1) Sprinkler #2
 - 1. P = 12.373
 - 2. K = 5.6
 - 3. Q = 19.7
- 2) Pipe #2
 - 1. Q = 19.5 + 19.7 = 39.2
 - 2. C = 120
 - 3. D = 1.380
 - 4. L = 2
 - 5. Fitting = None
 - 6. Elevation = 0

15) Step #2

1	1 - 2	12.13	19.5	19.5	120	1.049	2		2	0.124	0.248			12.373
2	2 - 3	12.37												
3	3 - 4													
4	4 - 5													
5	5 - 6													

S _o	N _{od}	P _{ini} al	Q _{ad} ded	Q _{rot} al	C _{Fact} or	D _{ame} ter	L _{epi} gh	F _{fl} ngs	E _{ov} L	L _{To} total	P _{friction} Loss	P _{friction} Loss x E _{ovL}	L _{Vertical}	P _{friction} Loss + P _{elevat} on + P _{Total}
1	1 - 2	12.13	19.5	19.5	120	1.049	2		2	0.124	0.248			12.373
2	2 - 3	12.37	19.7											
3	3 - 4													
4	4 - 5													
5	5 - 6													

S _o	N _{od}	P _{ini} al	Q _{ad} ded	Q _{rot} al	C _{Fact} or	D _{ame} ter	L _{epi} gh	F _{fl} ngs	E _{ov} L	L _{To} total	P _{friction} Loss	P _{friction} Loss x E _{ovL}	L _{Vertical}	P _{friction} Loss + P _{elevat} on + P _{Total}
1	1 - 2	12.13	19.5	19.5	120	1.049	2		2	0.124	0.248			12.373
2	2 - 3	12.37	19.7	39.2										
3	3 - 4													
4	4 - 5													
5	5 - 6													

S _{sp}	N _{od}	P _{ini} al	Q _{ad} ded	Q _{rot} al	C _{fact} or	D _{flame}	L _{epi} gh	F _{fl} nps	E _{QV} L	L _{To} total	P _{friction} Loss	L _{Vertical}	P _{friction} Loss x E _{QV,L}	L _{Vertical} 1 x 0.434 + P _{elevat} on + P _{Total}
1	1 - 2	12.13	19.5	19.5	120	1.049	2			2	0.124	0.248		12.373
2	2 - 3	12.37	19.7	39.2	120	1.38								
3	3 - 4													
4	4 - 5													
5	5 - 6													

S _{sp}	N _{od}	P _{ini} al	Q _{ad} ded	Q _{rot} al	C _{fact} or	D _{flame}	L _{epi} gh	F _{fl} nps	E _{QV} L	L _{To} total	P _{friction} Loss	L _{Vertical}	P _{friction} Loss x E _{QV,L}	L _{Vertical} 1 x 0.434 + P _{elevat} on + P _{Total}
1	1 - 2	12.13	19.5	19.5	120	1.049	2			2	0.124	0.248		12.373
2	2 - 3	12.37	19.7	39.2	120	1.38								
3	3 - 4													
4	4 - 5													
5	5 - 6													

S _{sp}	N _{od}	P _{ini} al	Q _{ad} ded	Q _{rot} al	C _{fact} or	D _{flame}	L _{epi} gh	F _{fl} nps	E _{QV} L	L _{To} total	P _{friction} Loss	L _{Vertical}	P _{friction} Loss x E _{QV,L}	L _{Vertical} 1 x 0.434 + P _{elevat} on + P _{Total}
1	1 - 2	12.13	19.5	19.5	120	1.049	2			2	0.124	0.248		12.373
2	2 - 3	12.37	19.7	39.2	120	1.38	2							
3	3 - 4													
4	4 - 5													
5	5 - 6													

S _{sp}	N _{od}	P _{ini} al	Q _{ad} ded	Q _{rot} al	C _{fact} or	D _{ame} ter	L _{epi} gh	F _{fl} rags	E _{QV} L	L _{To} total	P _{friction} Loss	L _{Vertical}	P _{friction} Loss x E _{QV,L}	L _{Vertical} 1 x 0.434 + P _{elevat} on + P _{Total}
1	1 - 2	12.13	19.5	19.5	120	1.049	2			2	0.124	0.248		12.373
2	2 - 3	12.37	19.7	39.2	120	1.38	2			2	0.119			
3	3 - 4													
4	4 - 5													
5	5 - 6													

S _{sp}	N _{od}	P _{ini} al	Q _{ad} ded	Q _{rot} al	C _{fact} or	D _{ame} ter	L _{epi} gh	F _{fl} rags	E _{QV} L	L _{To} total	P _{friction} Loss	L _{Vertical}	P _{friction} Loss x E _{QV,L}	L _{Vertical} 1 x 0.434 + P _{elevat} on + P _{Total}
1	1 - 2	12.13	19.5	19.5	120	1.049	2			2	0.124	0.248		12.373
2	2 - 3	12.37	19.7	39.2	120	1.38	2			2	0.119			
3	3 - 4													
4	4 - 5													
5	5 - 6													

S _{sp}	N _{od}	P _{ini} al	Q _{ad} ded	Q _{rot} al	C _{fact} or	D _{ame} ter	L _{epi} gh	F _{fl} rags	E _{QV} L	L _{To} total	P _{friction} Loss	L _{Vertical}	P _{friction} Loss x E _{QV,L}	L _{Vertical} 1 x 0.434 + P _{elevat} on + P _{Total}
1	1 - 2	12.13	19.5	19.5	120	1.049	2			2	0.124	0.248		12.373
2	2 - 3	12.37	19.7	39.2	120	1.38	2			2	0.119	0.224		
3	3 - 4													
4	4 - 5													
5	5 - 6													

S. no.	N. od	P. in	Q. des	Q. at	C. act	D. diam	L. ft	F. re	E. qvl	L. el	P. friction Loss	L. vertical	P. friction Loss x E. qvl	L. vertical + P. elevat on + P. total
1	1 - 2	12.13	19.5	19.5	120	1.049	2			2	0.124	0.248		12.373
2	2 - 3	12.37	19.7	39.2	120	1.38	2			2	0.119	0.234		12.611
3	3 - 4													
4	4 - 5													
5	5 - 6													

16) Attach Pipe #2 to Tee

- 1) Sprinkler #3
 - 1. P = 12.611
 - 2. K = 5.6
 - 3. Q = 19.9
 - 4. Sidewall Sprinkler – Is P sufficient for listing ?
 - 5. Review Vitaulic 40.11 pg 4
- 2) Pipe # 3
 - 1. Q = 39.2 + 19.9 = 59.1
 - 2. C = 120
 - 3. D = 1.610
 - 4. L = 2
 - 5. Fitting = None
 - 6. Elevation = 0

17) Step #3

S _{no}	N _{od}	P _{ini} al	Q _{ad} ded	Q _{rot} al	C _{fact} or	D _{flame} ter	L _{epi} gh	F _{fl} rps	E _{QV} L	L _{To} total	P _{friction} Loss	L _{Vertical}	P _{friction} Loss x E _{QV,L}	L _{Vertical} 1 x 0.434 + P _{elevat} on + P _{Total}
1	1 - 2	12.13	19.5	19.5	120	1.049	2			2	0.124	0.248		12.373
2	2 - 3	12.37	19.7	39.2	120	1.38	2			2	0.119	0.234		12.611
3	3 - 4	12.61	19.9											
4	4 - 5													
5	5 - 6													

S _{no}	N _{od}	P _{ini} al	Q _{ad} ded	Q _{rot} al	C _{fact} or	D _{flame} ter	L _{epi} gh	F _{fl} rps	E _{QV} L	L _{To} total	P _{friction} Loss	L _{Vertical}	P _{friction} Loss x E _{QV,L}	L _{Vertical} 1 x 0.434 + P _{elevat} on + P _{Total}
1	1 - 2	12.13	19.5	19.5	120	1.049	2			2	0.124	0.248		12.373
2	2 - 3	12.37	19.7	39.2	120	1.38	2			2	0.119	0.234		12.611
3	3 - 4	12.61	19.9	59.1										
4	4 - 5													
5	5 - 6													

S _{no}	N _{od}	P _{ini} al	Q _{ad} ded	Q _{rot} al	C _{fact} or	D _{flame} ter	L _{epi} gh	F _{fl} rps	E _{QV} L	L _{To} total	P _{friction} Loss	L _{Vertical}	P _{friction} Loss x E _{QV,L}	L _{Vertical} 1 x 0.434 + P _{elevat} on + P _{Total}
1	1 - 2	12.13	19.5	19.5	120	1.049	2			2	0.124	0.248		12.373
2	2 - 3	12.37	19.7	39.2	120	1.38	2			2	0.119	0.234		12.611
3	3 - 4	12.61	19.9	59.1										
4	4 - 5													
5	5 - 6													

S _{sp}	N _{od}	P _{ini} al	Q _{ad} ded	Q _{rot} al	C _{fact} or	D _{flame} ter	L _{epi} gh	F _{fl} rps	E _{QV} L	L _{To} total	P _{friction} Loss	L _{Vertical}	P _{friction} Loss x E _{QV,L}	L _{Vertical} 1 x 0.434 + P _{elevat} on + P _{Total}
1	1 - 2	12.13	19.5	19.5	120	1.049	2			2	0.124	0.248		12.373
2	2 - 3	12.37	19.7	39.2	120	1.38	2			2	0.119	0.234		12.611
3	3 - 4	12.61	19.9	59.1	120									
4	4 - 5													
5	5 - 6													

S _{sp}	N _{od}	P _{ini} al	Q _{ad} ded	Q _{rot} al	C _{fact} or	D _{flame} ter	L _{epi} gh	F _{fl} rps	E _{QV} L	L _{To} total	P _{friction} Loss	L _{Vertical}	P _{friction} Loss x E _{QV,L}	L _{Vertical} 1 x 0.434 + P _{elevat} on + P _{Total}
1	1 - 2	12.13	19.5	19.5	120	1.049	2			2	0.124	0.248		12.373
2	2 - 3	12.37	19.7	39.2	120	1.38	2			2	0.119	0.234		12.611
3	3 - 4	12.61	19.9	59.1	120	1.61	2							
4	4 - 5													
5	5 - 6													

S _{sp}	N _{od}	P _{ini} al	Q _{ad} ded	Q _{rot} al	C _{fact} or	D _{flame} ter	L _{epi} gh	F _{fl} rps	E _{QV} L	L _{To} total	P _{friction} Loss	L _{Vertical}	P _{friction} Loss x E _{QV,L}	L _{Vertical} 1 x 0.434 + P _{elevat} on + P _{Total}
1	1 - 2	12.13	19.5	19.5	120	1.049	2			2	0.124	0.248		12.373
2	2 - 3	12.37	19.7	39.2	120	1.38	2			2	0.119	0.234		12.611
3	3 - 4	12.61	19.9	59.1	120	1.61	2							
4	4 - 5													
5	5 - 6													

S _{sp}	N _{od}	P _{ini} al	Q _{ad} ded	Q _{rot} al	C _{fact} or	D _{flame} ter	L _{epi} gh	F _{fl} rags	E _{QV} L	L _{To} total	P _{friction} Loss	L _{Vertical}	P _{friction} Loss x E _{QV,L}	L _{Vertical} 1 x 0.434 + P _{elevat} on + P _{Total}
1	1 - 2	12.13	19.5	19.5	120	1.049	2			2	0.124	0.248		12.373
2	2 - 3	12.37	19.7	39.2	120	1.38	2			2	0.119	0.234		12.611
3	3 - 4	12.61	19.9	59.1	120	1.61	2			2				
4	4 - 5													
5	5 - 6													

S _{sp}	N _{od}	P _{ini} al	Q _{ad} ded	Q _{rot} al	C _{fact} or	D _{flame} ter	L _{epi} gh	F _{fl} rags	E _{QV} L	L _{To} total	P _{friction} Loss	L _{Vertical}	P _{friction} Loss x E _{QV,L}	L _{Vertical} 1 x 0.434 + P _{elevat} on + P _{Total}
1	1 - 2	12.13	19.5	19.5	120	1.049	2			2	0.124	0.248		12.373
2	2 - 3	12.37	19.7	39.2	120	1.38	2			2	0.119	0.234		12.611
3	3 - 4	12.61	19.9	59.1	120	1.61	2			2	0.12			
4	4 - 5													
5	5 - 6													

S _{sp}	N _{od}	P _{ini} al	Q _{ad} ded	Q _{rot} al	C _{fact} or	D _{flame} ter	L _{epi} gh	F _{fl} rags	E _{QV} L	L _{To} total	P _{friction} Loss	L _{Vertical}	P _{friction} Loss x E _{QV,L}	L _{Vertical} 1 x 0.434 + P _{elevat} on + P _{Total}
1	1 - 2	12.13	19.5	19.5	120	1.049	2			2	0.124	0.248		12.373
2	2 - 3	12.37	19.7	39.2	120	1.38	2			2	0.119	0.234		12.611
3	3 - 4	12.61	19.9	59.1	120	1.61	2			2	0.12	0.24		
4	4 - 5													
5	5 - 6													

S. no.	Nod e	P _{in} at node	Q _c dis-	Q _c at node	C _{fact}	D _{name}	L _{in} gpm	F _{re} mpa	L _{total}	P _{friction} Loss	L _{Vertical}	P _{friction} Loss x E _{QV}	L _{Vertical} + P _{elevat} on + P _{T-dia}
1	1 - 2	12.13	19.5	19.5	120	1.049	2			2	0.124	0.248	
													12.373
2	2 - 3	12.37	19.7	39.2	120	1.38	2			2	0.119	0.234	
													12.611
3	3 - 4	12.61	19.9	59.1	120	1.61	2			2	0.12	0.24	
													12.851
4	4 - 5												
5	5 - 6												

18) Attach Pipe #3 to Tee

- 1) Sprinkler # 4
 - 1. P = 12.851
 - 2. K = 5.6
 - 3. Q = 20.1
- 2) Pipe # 4
 - 1. Q = 59.1 + 20.1 = 79.2
 - 2. C = 120
 - 3. D = 2.067
 - 4. L = 2 +1
 - 5. Fitting = 2 Tees
 - 6. Elevation = 1

19) Step #4

S _{sp}	N _{od}	P _{ini} al	Q _{ad} ded	Q _{rot} al	C _{fact} or	D _{flame} ter	L _{epi} gh	F _{fl} rps	E _{QV} L	L _{To} total	P _{friction} Loss	L _{Vertical}	P _{friction} Loss x E _{QV,L}	L _{Vertical} 1 x 0.434 + P _{elevat} on + P _{Total}
1	1 - 2	12.13	19.5	19.5	120	1.049	2			2	0.124	0.248		12.373
2	2 - 3	12.37	19.7	39.2	120	1.38	2			2	0.119	0.234		12.611
3	3 - 4	12.61	19.9	59.1	120	1.61	2			2	0.12	0.24		12.851
4	4 - 5	12.85	20.1	79.2										
5	5 - 6													

S _{sp}	N _{od}	P _{ini} al	Q _{ad} ded	Q _{rot} al	C _{fact} or	D _{flame} ter	L _{epi} gh	F _{fl} rps	E _{QV} L	L _{To} total	P _{friction} Loss	L _{Vertical}	P _{friction} Loss x E _{QV,L}	L _{Vertical} 1 x 0.434 + P _{elevat} on + P _{Total}
1	1 - 2	12.13	19.5	19.5	120	1.049	2			2	0.124	0.248		12.373
2	2 - 3	12.37	19.7	39.2	120	1.38	2			2	0.119	0.234		12.611
3	3 - 4	12.61	19.9	59.1	120	1.61	2			2	0.12	0.24		12.851
4	4 - 5	12.85	20.1	79.2										
5	5 - 6													

S _{sp}	N _{od}	P _{ini} al	Q _{ad} ded	Q _{rot} al	C _{fact} or	D _{flame} ter	L _{epi} gh	F _{fl} rps	E _{QV} L	L _{To} total	P _{friction} Loss	L _{Vertical}	P _{friction} Loss x E _{QV,L}	L _{Vertical} 1 x 0.434 + P _{elevat} on + P _{Total}
1	1 - 2	12.13	19.5	19.5	120	1.049	2			2	0.124	0.248		12.373
2	2 - 3	12.37	19.7	39.2	120	1.38	2			2	0.119	0.234		12.611
3	3 - 4	12.61	19.9	59.1	120	1.61	2			2	0.12	0.24		12.851
4	4 - 5	12.85	20.1	79.2										
5	5 - 6													

S _{sp}	N _{od}	P _{ini} al	Q _{ad} ded	Q _{rot} al	C _{fact} or	D _{lame} ter	L _{epi} gh	F _{fl} nps	E _{QV} L	L _{To} total	P _{friction} Loss	L _{Vertical}	P _{friction} Loss x E _{QV,L}	L _{Vertical} 1 x 0.434 + P _{elevat} on + P _{Total}
1	1 - 2	12.13	19.5	19.5	120	1.049	2			2	0.124	0.248		12.373
2	2 - 3	12.37	19.7	39.2	120	1.38	2			2	0.119	0.234		12.611
3	3 - 4	12.61	19.9	59.1	120	1.61	2			2	0.12	0.24		12.851
4	4 - 5	12.85	20.1	79.2	120	2.067	2							
5	5 - 6													

S _{sp}	N _{od}	P _{ini} al	Q _{ad} ded	Q _{rot} al	C _{fact} or	D _{lame} ter	L _{epi} gh	F _{fl} nps	E _{QV} L	L _{To} total	P _{friction} Loss	L _{Vertical}	P _{friction} Loss x E _{QV,L}	L _{Vertical} 1 x 0.434 + P _{elevat} on + P _{Total}
1	1 - 2	12.13	19.5	19.5	120	1.049	2			2	0.124	0.248		12.373
2	2 - 3	12.37	19.7	39.2	120	1.38	2			2	0.119	0.234		12.611
3	3 - 4	12.61	19.9	59.1	120	1.61	2			2	0.12	0.24		12.851
4	4 - 5	12.85	20.1	79.2	120	2.067	2							
5	5 - 6													

S _{sp}	N _{od}	P _{ini} al	Q _{ad} ded	Q _{rot} al	C _{fact} or	D _{lame} ter	L _{epi} gh	F _{fl} nps	E _{QV} L	L _{To} total	P _{friction} Loss	L _{Vertical}	P _{friction} Loss x E _{QV,L}	L _{Vertical} 1 x 0.434 + P _{elevat} on + P _{Total}
1	1 - 2	12.13	19.5	19.5	120	1.049	2			2	0.124	0.248		12.373
2	2 - 3	12.37	19.7	39.2	120	1.38	2			2	0.119	0.234		12.611
3	3 - 4	12.61	19.9	59.1	120	1.61	2			2	0.12	0.24		12.851
4	4 - 5	12.85	20.1	79.2	120	2.067	2							
5	5 - 6													

S_{sp}	Nod	P_{ini}	Q_{ded}	Q_{tot}	C_{fact}	D _{name}	L _{en}	F _{ri}	E_{QVL}	L _{to}	P_{friction}	L _{Vertical}	P_{friction} $i \times 0.434$ Loss x E_{QVL}	P_{friction} + P_{elevat}^{on} $\rightarrow P_{\text{Total}}$
1	1 - 2	12.13	19.5	19.5	120	1.049	2			2	0.124	0.248		12.373
2	2 - 3	12.37	19.7	39.2	120	1.38	2			2	0.119	0.234		12.611
3	3 - 4	12.61	19.9	59.1	120	1.61	2			2	0.12	0.24		12.851
4	4 - 5	12.85	20.1	79.2	120	2.067	3	T, T	30x2					
5	5 - 6													

S_{sp}	Nod	P_{ini}	Q_{ded}	Q_{tot}	C_{fact}	D _{name}	L _{en}	F _{ri}	E_{QVL}	L _{to}	P_{friction}	L _{Vertical}	P_{friction} $i \times 0.434$ Loss x E_{QVL}	P_{friction} + P_{elevat}^{on} $\rightarrow P_{\text{Total}}$
1	1 - 2	12.13	19.5	19.5	120	1.049	2			2	0.124	0.248		12.373
2	2 - 3	12.37	19.7	39.2	120	1.38	2			2	0.119	0.234		12.611
3	3 - 4	12.61	19.9	59.1	120	1.61	2			2	0.12	0.24		12.851
4	4 - 5	12.85	20.1	79.2	120	2.067	3	T, T	30x2					
5	5 - 6													

S_{sp}	Nod	P_{ini}	Q_{ded}	Q_{tot}	C_{fact}	D _{name}	L _{en}	F _{ri}	E_{QVL}	L _{to}	P_{friction}	L _{Vertical}	P_{friction} $i \times 0.434$ Loss x E_{QVL}	P_{friction} + P_{elevat}^{on} $\rightarrow P_{\text{Total}}$
1	1 - 2	12.13	19.5	19.5	120	1.049	2			2	0.124	0.248		12.373
2	2 - 3	12.37	19.7	39.2	120	1.38	2			2	0.119	0.234		12.611
3	3 - 4	12.61	19.9	59.1	120	1.61	2			2	0.12	0.24		12.851
4	4 - 5	12.85	20.1	79.2	120	2.067	3	T, T	10x2					
5	5 - 6													

S_{sp}	N_{tot}	P_{init}	Q_{ad}	Q_{tot}	C_{fact}	D_{dame}	L_{en}	F_{fl}	E_{QVL}	L_{to}	P_{friction}	L_{vertical}	$P_{\text{friction}} \times 0.434$	P_{friction}	$P_{\text{elevation}}$	P_{total}
1	1 - 2	12.13	19.5	19.5	120	1.049	2			2	0.124	0.248				12.373
2	2 - 3	12.37	19.7	39.2	120	1.38	2			2	0.119	0.234				12.611
3	3 - 4	12.61	19.9	59.1	120	1.61	2			2	0.12	0.24				12.851
4	4 - 5	12.85	20.1	79.2	120	2.067	3	T, T	10 x 2	23	0.061	1.4				
5	5 - 6															

S_{sp}	N_{tot}	P_{init}	Q_{ad}	Q_{tot}	C_{fact}	D_{dame}	L_{en}	F_{fl}	E_{QVL}	L_{to}	P_{friction}	L_{vertical}	$P_{\text{friction}} \times 0.434$	P_{friction}	$P_{\text{elevation}}$	P_{total}
1	1 - 2	12.13	19.5	19.5	120	1.049	2			2	0.124	0.248				12.373
2	2 - 3	12.37	19.7	39.2	120	1.38	2			2	0.119	0.234				12.611
3	3 - 4	12.61	19.9	59.1	120	1.61	2			2	0.12	0.24				12.851
4	4 - 5	12.85	20.1	79.2	120	2.067	3	T, T	10 x 2	23	0.061	1.4				
5	5 - 6															

S_{sp}	N_{tot}	P_{init}	Q_{ad}	Q_{tot}	C_{fact}	D_{dame}	L_{en}	F_{fl}	E_{QVL}	L_{to}	P_{friction}	L_{vertical}	$P_{\text{friction}} \times 0.434$	P_{friction}	$P_{\text{elevation}}$	P_{total}
1	1 - 2	12.13	19.5	19.5	120	1.049	2			2	0.124	0.248				12.373
2	2 - 3	12.37	19.7	39.2	120	1.38	2			2	0.119	0.234				12.611
3	3 - 4	12.61	19.9	59.1	120	1.61	2			2	0.12	0.24				12.851
4	4 - 5	12.85	20.1	79.2	120	2.067	3	T, T	10 x 2	23	0.061	1.4				
5	5 - 6															

S_{sp}	N_{of}	P_{ini} at end	Q_{de} at end	Q_{Tot} at or	C_{fact} ter	Diam_e	L_{en} gth	F_{ri} mpa	E_{QVL}	L_{To} at	P_{friction} Loss	L_{Vertical}	P_{friction} Loss X E_{QVL}	L_{Vertical}	P_{friction} Loss + P_{elevation} on/Elevat	P_{Total}
1	1 - 2	12.13	19.5	19.5	120	1.049	2			2	0.124	0.248				12.373
2	2 - 3	12.37	19.7	39.2	120	1.38	2			2	0.119	0.234				12.611
3	3 - 4	12.61	19.9	59.1	120	1.61	2			2	0.12	0.24				12.851
4	4 - 5	12.85	20.1	79.2	120	2.067	3	T, T	10 x 2	23	0.061	1.4	1	0.434		
5	5 - 6															

S_{sp}	N_{of}	P_{ini} at end	Q_{de} at end	Q_{Tot} at or	C_{fact} ter	Diam_e	L_{en} gth	F_{ri} mpa	E_{QVL}	L_{To} at	P_{friction} Loss	L_{Vertical}	P_{friction} Loss X E_{QVL}	L_{Vertical}	P_{friction} Loss + P_{elevation} on/Elevat	P_{Total}
1	1 - 2	12.13	19.5	19.5	120	1.049	2			2	0.124	0.248				12.373
2	2 - 3	12.37	19.7	39.2	120	1.38	2			2	0.119	0.234				12.611
3	3 - 4	12.61	19.9	59.1	120	1.61	2			2	0.12	0.24				12.851
4	4 - 5	12.85	20.1	79.2	120	2.067	3	T, T	10 x 2	23	0.061	1.4	1	0.434	14.688	
5	5 - 6															

20) Attach Pipe # 4 to Tee

- 1) Sprinkler # 5 - None
- 2) Pipe # 5
 - 1. Q = 79.2
 - 2. C = 120
 - 3. D = 4.026
 - 4. L = 10
 - 5. Fitting = None
 - 6. Elevation = 0

21) Step #5

S_{sp}	N_{tot}	P_{ini}	Q_{ad}	Q_{tot}	C_{fact}	D_{dame}	L_{en}	F_{fl}	E_{QVL}	L_{to}	$P_{friction}$	$L_{vertical}$	$P_{friction}$ $i \times 0.434$ Loss X E_{QVL}
		at	ded	at	or	ter	gh	ings		tal	Loss	on	$=$ $P_{elevation}$ $+ P_{total}$
1	1 - 2	12.13	19.5	19.5	120	1.049	2			2	0.124	0.248	
													12.373
2	2 - 3	12.37	19.7	39.2	120	1.38	2			2	0.119	0.234	
													12.611
3	3 - 4	12.61	19.9	59.1	120	1.61	2			2	0.12	0.24	
													12.851
4	4 - 5	12.85	20.1	79.2	120	2.067	3	T, T	10 x 2	23	0.061	1.4	1
													0.434
5	5 - 6	14.69											14.688

S_{sp}	N_{tot}	P_{ini}	Q_{ad}	Q_{tot}	C_{fact}	D_{dame}	L_{en}	F_{fl}	E_{QVL}	L_{to}	$P_{friction}$	$L_{vertical}$	$P_{friction}$ $i \times 0.434$ Loss X E_{QVL}
		at	ded	at	or	ter	gh	ings		tal	Loss	on	$=$ $P_{elevation}$ $+ P_{total}$
1	1 - 2	12.13	19.5	19.5	120	1.049	2			2	0.124	0.248	
													12.373
2	2 - 3	12.37	19.7	39.2	120	1.38	2			2	0.119	0.234	
													12.611
3	3 - 4	12.61	19.9	59.1	120	1.61	2			2	0.12	0.24	
													12.851
4	4 - 5	12.85	20.1	79.2	120	2.067	3	T, T	10 x 2	23	0.061	1.4	1
													0.434
5	5 - 6	14.69	0										14.688

S_{sp}	N_{tot}	$P_{\text{neti}} \text{ at}$	$Q_{\text{ad}} \text{ ded}$	Q_{tot}	C_{fact}	D_{dame}	L_{en}	F_{fl}	E_{QVL}	L_{to}	P_{friction}	L_{vertical}	$P_{\text{friction}} \text{ Loss} \times$	P_{friction}	
													L_{vertical}	$i \times 0.434$	P_{friction}
1	1 - 2	12.13	19.5	19.5	120	1.049	2			2	0.124	0.248			12.373
2	2 - 3	12.37	19.7	39.2	120	1.38	2			2	0.119	0.234			12.611
3	3 - 4	12.61	19.9	59.1	120	1.61	2			2	0.12	0.24			12.851
4	4 - 5	12.85	20.1	79.2	120	2.067	3	T, T	10 x 2	23	0.061	1.4	1	0.434	14.688
5	5 - 6	14.69	0	79.2	120	1.026									

S_{sp}	N_{tot}	$P_{\text{neti}} \text{ at}$	$Q_{\text{ad}} \text{ ded}$	Q_{tot}	C_{fact}	D_{dame}	L_{en}	F_{fl}	E_{QVL}	L_{to}	P_{friction}	L_{vertical}	$P_{\text{friction}} \text{ Loss} \times$	P_{friction}	
													L_{vertical}	$i \times 0.434$	P_{friction}
1	1 - 2	12.13	19.5	19.5	120	1.049	2			2	0.124	0.248			12.373
2	2 - 3	12.37	19.7	39.2	120	1.38	2			2	0.119	0.234			12.611
3	3 - 4	12.61	19.9	59.1	120	1.61	2			2	0.12	0.24			12.851
4	4 - 5	12.85	20.1	79.2	120	2.067	3	T, T	10 x 2	23	0.061	1.4	1	0.434	14.688
5	5 - 6	14.69	0	79.2	120	1.026									

S_{sp}	N_{tot}	$P_{\text{neti}} \text{ at}$	$Q_{\text{ad}} \text{ ded}$	Q_{tot}	C_{fact}	D_{dame}	L_{en}	F_{fl}	E_{QVL}	L_{to}	P_{friction}	L_{vertical}	$P_{\text{friction}} \text{ Loss} \times$	P_{friction}	
													L_{vertical}	$i \times 0.434$	P_{friction}
1	1 - 2	12.13	19.5	19.5	120	1.049	2			2	0.124	0.248			12.373
2	2 - 3	12.37	19.7	39.2	120	1.38	2			2	0.119	0.234			12.611
3	3 - 4	12.61	19.9	59.1	120	1.61	2			2	0.12	0.24			12.851
4	4 - 5	12.85	20.1	79.2	120	2.067	3	T, T	10 x 2	23	0.061	1.4	1	0.434	14.688
5	5 - 6	14.69	0	79.2	120	1.026									

S_{sp}	N_{tot}	$P_{\text{neti}} \text{ at}$	$Q_{\text{ad}} \text{ ded}$	Q_{tot}	C_{fact}	D_{dame}	L_{en}	F_{fl}	E_{QVL}	L_{to}	P_{friction}	L_{vertical}	$P_{\text{friction}} \text{ Loss} \times$	P_{friction}	
													$I \times 0.434$	P_{friction}	
													$+ P_{\text{elevation}}$	$= P_{\text{total}}$	
1	1 - 2	12.13	19.5	19.5	120	1.049	2			2	0.124	0.248		12.373	
2	2 - 3	12.37	19.7	39.2	120	1.38	2			2	0.119	0.234		12.611	
3	3 - 4	12.61	19.9	59.1	120	1.61	2			2	0.12	0.24		12.851	
4	4 - 5	12.85	20.1	79.2	120	2.067	3	T, T	10 x 2	23	0.061	1.4	1	0.434	14.688
5	5 - 6	14.69	0	79.2	120	4.026	10			10	0.002				

S_{sp}	N_{tot}	$P_{\text{neti}} \text{ at}$	$Q_{\text{ad}} \text{ ded}$	Q_{tot}	C_{fact}	D_{dame}	L_{en}	F_{fl}	E_{QVL}	L_{to}	P_{friction}	L_{vertical}	$P_{\text{friction}} \text{ Loss} \times$	P_{friction}	
													$I \times 0.434$	P_{friction}	
													$+ P_{\text{elevation}}$	$= P_{\text{total}}$	
1	1 - 2	12.13	19.5	19.5	120	1.049	2			2	0.124	0.248		12.373	
2	2 - 3	12.37	19.7	39.2	120	1.38	2			2	0.119	0.234		12.611	
3	3 - 4	12.61	19.9	59.1	120	1.61	2			2	0.12	0.24		12.851	
4	4 - 5	12.85	20.1	79.2	120	2.067	3	T, T	10 x 2	23	0.061	1.4	1	0.434	14.688
5	5 - 6	14.69	0	79.2	120	4.026	10			10	0.002				

S_{sp}	N_{tot}	$P_{\text{neti}} \text{ at}$	$Q_{\text{ad}} \text{ ded}$	Q_{tot}	C_{fact}	D_{dame}	L_{en}	F_{fl}	E_{QVL}	L_{to}	P_{friction}	L_{vertical}	$P_{\text{friction}} \text{ Loss} \times$	P_{friction}	
													$I \times 0.434$	P_{friction}	
													$+ P_{\text{elevation}}$	$= P_{\text{total}}$	
1	1 - 2	12.13	19.5	19.5	120	1.049	2			2	0.124	0.248		12.373	
2	2 - 3	12.37	19.7	39.2	120	1.38	2			2	0.119	0.234		12.611	
3	3 - 4	12.61	19.9	59.1	120	1.61	2			2	0.12	0.24		12.851	
4	4 - 5	12.85	20.1	79.2	120	2.067	3	T, T	10 x 2	23	0.061	1.4	1	0.434	14.688
5	5 - 6	14.69	0	79.2	120	4.026	10			10	0.002				

S_{sp}	N _{tot}	P _{inlet} at bed	Q _{out} at bed	Q _{tot} at or	C _{fact} ter	D _{dame} ghn	L _{en} m	F _{fric} mpa	E _{QVL}	L _{to} tail	P _{friction} Loss	L _{Vertical}	$P_{friction}$ $I \times 0.434$ Loss x E _{QVL}	$P_{friction}$ + $P_{elevation}$ on/Elevat	P_{Total}
1	1 - 2	12.13	19.5	19.5	120	1.049	2			2	0.124	0.248			12.373
2	2 - 3	12.37	19.7	39.2	120	1.38	2			2	0.119	0.234			12.611
3	3 - 4	12.61	19.9	59.1	120	1.61	2			2	0.12	0.24			12.851
4	4 - 5	12.85	20.1	79.2	120	2.067	3	T, T	10 x 2	23	0.061	1.4	1	0.434	14.688
5	5 - 6	14.69	0	79.2	120	4.026	10			10	0.002	0.024			

S_{sp}	N _{tot}	P _{inlet} at bed	Q _{out} at bed	Q _{tot} at or	C _{fact} ter	D _{dame} ghn	L _{en} m	F _{fric} mpa	E _{QVL}	L _{to} tail	P _{friction} Loss	L _{Vertical}	$P_{friction}$ $I \times 0.434$ Loss x E _{QVL}	$P_{friction}$ + $P_{elevation}$ on/Elevat	P_{Total}
1	1 - 2	12.13	19.5	19.5	120	1.049	2			2	0.124	0.248			12.373
2	2 - 3	12.37	19.7	39.2	120	1.38	2			2	0.119	0.234			12.611
3	3 - 4	12.61	19.9	59.1	120	1.61	2			2	0.12	0.24			12.851
4	4 - 5	12.85	20.1	79.2	120	2.067	3	T, T	10 x 2	23	0.061	1.4	1	0.434	14.688
5	5 - 6	14.69	0	79.2	120	4.026	10			10	0.002	0.024			14.69

23) Identical Branch Lines

Modified K Factor shortcut

$$Q = K P^{1/2}$$

$$K = Q/P^{1/2}$$

$$K = 79.2/(14.688^{1/2})$$

$$K = 20.665$$

$$Q_{new} = K_{modified} \times P^{1/2}_{new}$$

$$Q_{new} = 20.665 \times 14.69^{1/2}$$

$$Q_{new} = 79.203$$

Hydraulic Work Sheets

CONTRACT NAME _____		SHEET _____ OF _____								
STEP NO.	NOZZLE IDENT. AND LOCATION	FLOW IN G.P.M.	PIPE SIZE	FITTINGS AND DEVICES	EQUIV. PIPE LENGTH	FRICTION LOSS P.S.I./FOOT	PRESSURE SUMMARY	NORMAL PRESSURE	NOTES	REF. STEP
		q			L	P_f	P_t			
		Q			F	P_e	P_v			
					T	P_f	P_n			
		q			L	P_f	P_t			
		Q			F	P_e	P_v			
					T	P_f	P_n			
		q			L	P_f	P_t			
		Q			F	P_e	P_v			
					T	P_f	P_n			
		q			L	P_f	P_t			
		Q			F	P_e	P_v			
					T	P_f	P_n			

Most calculations are generated from computer programs. While each program may differ slightly as to the layout, all programs must provide certain necessary information.

Step Number

STEP NO.	NOZZLE IDENT. AND LOCATION
1	

The purpose of the Step Numbers are to depict the sequence of the hydraulic calculation process. This ensures that a step was not accidentally missed, omitted or forgotten.

This example shows Step # 1

Nozzle Identification and Location

STEP NO.	NOZZLE IDENT. AND LOCATION
1	1 BL-1

The Nozzle Identification & Location column is used to demonstrate the exact location of the hydraulic calculation with respect to the sprinkler plans

The sprinkler plans must identify exact reference or location points that are the same as the calculation worksheet

Nozzle Identification and Location Example

STEP NO.	NOZZLE IDENT. AND LOCATION	
1	1	BL 1

This example references sprinkler # 1 on branch line (BL) # 1

Flow in Gallons Per Minute

NOZZLE IDENT. AND LOCATION	FLOW IN G.P.M.
1	BL 1
	q
	Q

Using the alphabet "q" or "Q" as an abbreviation for quantity, this column is used to describe flows in g.p.m. at a given location "q" = g.p.m. flow at a specific location

"Q" = Combined or Overall g.p.m. flow at a specific location

Determine Remote Area

- Based on Classification / Commodity.
 - Lets choose Ordinary 1 (0.15 gpm/sq ft over 1500 ft²) SSP sprinkler
 - Based on diagram area per sprinkler is 10' X 13' = 130 ft²
 - Max spacing by area for Ord 1 based on table 8.6.2.2.1 (b). Allowed to be 15' apart but must have closer branch lines (8.33').

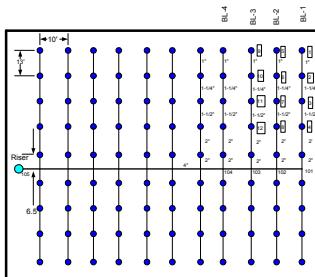
Calculate Total Sprinklers

$$Ts = \frac{\text{Design area}}{\text{Area per spkr}}$$

$$Ts = \frac{1500 \text{ ft}^2}{130 \text{ ft}^2} = 11.538$$

Round up to 12

$$Ts = 12$$



of sprinklers on a branch line (Ns)

$$Ns = \frac{(1.2) A^{1/2}}{S}$$

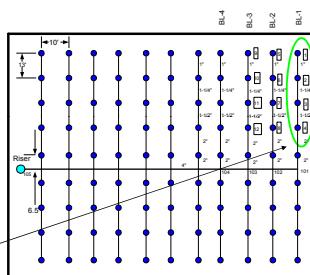
A= design area

S= Dist. Btw. Spkrs on a branch line

$$Ns = \frac{(1.2)(1500)^{1/2}}{13}$$

Ns = 3.57 Round up to 4

$$Ns = 4$$

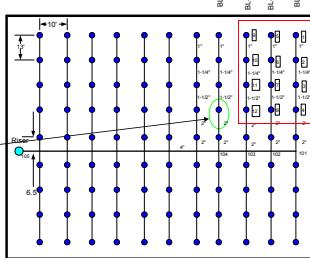


Number of Branch Lines

Since we need 4 sprinklers / branch line and a total of 12 sprinklers we need 3 branch lines. ($4 \times 3 = 12$)

Note: As a check
 $12 \times 130 \text{ ft}^2 = 1560 \text{ ft}^2$,
and $1560 \text{ ft}^2 > 1500 \text{ ft}^2$
so the area is covered!

If not add 1 sprinkler on the next branch line closest to the cross main, more hydraulically demanding higher pressure therefore more flow



Flow from 1st sprinkler

$$Q = (D) (A)$$

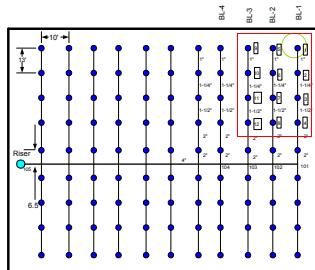
Q= flow in GPM

D=density selected

A= Area of operation of the sprinkler

$$Q_1 = (0.15 \text{ gpm/ft}^2)(130 \text{ ft}^2)$$

$$Q_1 = 19.5 \text{ GPM}$$



Pressure at 1st sprinkler

From previous slide $Q_1 = 19.5 \text{ gpm}$

Using basic formula $Q = K (P)^{1/2}$

Re-arrange formula to solve for 'P'

$$P = \left(\frac{Q}{K} \right)^2$$

For this example

$$P = \left(\frac{19.5}{5.6} \right)^2 = 12.12 \text{ psi}$$

NFPA 13 section 14.4.4.8.1 requires a minimum of 7 psi at the sprinkler, but at 7 psi the flow is only 14.8 gpm **too low**.

Lets start

- Basic Formula (FL)
 - Hazen Williams

$$P = \frac{(4.52) Q^{1.85}}{C^{1.85} d^{4.87}}$$

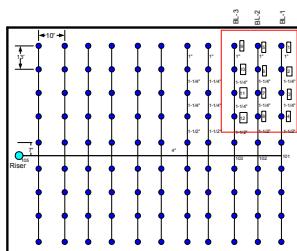
P= Pressure loss (psi)

Q= flow (gpm)

C= coef. of roughness

d= Diameter (inches)

(actual)



Flow from 1st sprinkler

$$Q = (D) (A)$$

Q = flow in GPM

D =density selected

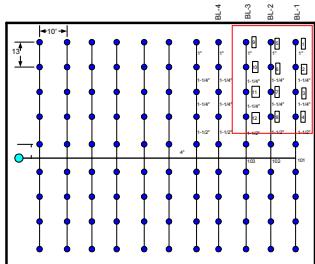
A = Area of operation of the sprinkler

$$Q_1=(0.15)(130)$$

$Q_1= 19.5 \text{ GPM}$

$$P_1= \left[\frac{Q}{k} \right]^2 = \left[\frac{19.5}{5.6} \right]^2$$

$P_1= 12.12 \text{ psi}$



Flow in Gallons Per Minute Example

NOZZLE IDENT. AND LOCATION	FLOW IN G.P.M.
1 BL 1	$q \ 19.5$ $Q \ 19.5$

This example shows a overall flow of 19.5 gallons per minute from sprinkler# 1 on branch line # 1.

Move on to head #2

Calculate friction loss in the pipe from head 1 to head 2 using Hazen Williams. Note use actual diameter of the pipe from table A.6.3.2 and assume 1" schedule 40 pipe.

$$P = \frac{(4.52) Q^{1.85}}{C^{1.85} D^{4.87}} \quad Q=19.5 \text{ gpm}, C=120, D=1.049"$$

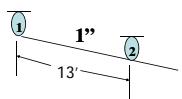
Solving for P , $P=0.124 \text{ psi/ft}$
Total for the 13 ft long pipe
 $(13)(0.124)= 1.62 \text{ psi friction loss in the pipe.}$

Total pressure at head 2 = $P_2 = 12.1 + 1.62 = 13.72 \text{ psi}$

Flow from head 2 $q_2=k(P_2)^{1/2} = 5.6(13.72)^{1/2} = 20.753 \text{ gpm}$

Flow in Gallons Per Minute

Example



NOZZLE IDENT. AND LOCATION		FLOW IN G.P.M.
1	BL 1	q 19.5
		Q 19.5
2	BL 1	20.7
		Q 40.24

This example shows a flow of 19.5 gpm from sprinkler #1 on branch line #1 and a flow of 20.7 gpm from sprinkler #2 for an overall flow of 40.24 gpm at sprinkler #2 on branch line #1

Pipe Size Column

NOZZLE IDENT. AND LOCATION		FLOW IN G.P.M.	PIPE SIZE
1	BL 1	q 19.5	1"
		Q 19.5	
2	BL 1	q + 20.7	1-1/4"
		Q 40.24	

The Pipe Size Column is used to describe pipe sizes between sprinklers or reference points

Pipe Fittings & Devices Column

NOZZLE IDENT. AND LOCATION		FLOW IN G.P.M.	PIPE SIZE	PIPE FITTINGS AND DEVICES
18	T.O.R	q	3"	1E = 7'
		Q 341		1 CV = 16'
19	B.O.R	q		1GV = 1'
		Q 341		

T.O.R. = Top of Riser
1 E = 1 Elbow
1 GV = 1 Gate Valve

B.O.R = Bottom of Riser
1 CV = 1 Check Valve

Equivalent Pipe Length

EQUIV. PIPE LENGTH
L 15
F + 24
T 39

L = Pipe Length between reference points

F = Equivalent Pipe Length for fittings and devices between reference points

T = Total Equivalent Length of pipe, fittings and devices

Used for determining Friction Loss between reference points for pipe, fittings and/or devices

Friction Loss P.S.I per Foot

EQUIV. PIPE LENGTH	FRICTION LOSS P.S.I. / FOOT
L 15	
F + 24	
T 39	

Using the Hazen Williams Formula for determining Pressure Loss per lineal ft. of pipe, this column is used to list the pressure loss due to friction per foot in p.s.i.

Friction Loss P.S.I per Foot

EQUIV. PIPE LENGTH	FRICTION LOSS P.S.I. / FOOT
L 15	
F + 24	
T 39	0.132

This example shows Pressure Loss due to friction per foot of pipe of 0.132 p.s.i.

Multiplying 39 feet of pipe X 0.132 = 5.17 p.s.i. between two reference points.

Pressure Summary Column

FRICITION LOSS P.S.I. / FOOT	PRESSURE SUMMARY
	Pt
	Pe
	Pf

Pt = Pressure Total at a specific reference point

Pe = Pressure Loss due to Elevation

Pf = Pressure Loss due to Friction

Pressure Summary Example

EQUIV. PIPE LENGTH	FRICITION LOSS P.S.I. / FOOT	PRESSURE SUMMARY
L 15		Pt 13
F + 24		Pe 4
T 39	0.85	Pf 5.17
		Pt 22.17

This Example Shows:

Pressure Total of 13 psi

Pressure Loss due to elevation of 4 psi

Pressure Loss due to friction (39 ft. X 0.132) of 5.17 psi

New Pressure Total at the next reference point of 22.17 psi.

Normal Pressure Column

NORMAL PRESSURE
Pt
Pv
Pn

This column is used when calculating Velocity Pressures

Pt. = Pressure Total

Pv = Velocity Pressure

Pn = Pressure Normal

EQUATION: Pt - Pv = Pn

The Notes Column is used to list additional information such as equations for Flows, Pressures, Elevation Pressure Losses and K-Factors.

NOTES		REF. STEP
$q = 4\sqrt{25} = 20$		

This example shows the equation for determining flow

CONTRACT NAME		February 2011 Career Development		OH-1		SHEET 1 OF 1						
STEP NO.	NOZZLE IDENT. AND LOCATION	FLOW IN G.P.M.	PIPE SIZE	PIPE FITTINGS AND DEVICES	EQUIV. PIPE LENGTH	FRICITION LOSS P.S.I./FOOT	PRESSURE SUMMARY	NORMAL PRESSURE	0.15 gpm/ft ²	NOTES	REF. STEP	
1	1 BL-1	19.5 q	1"	L 13' F ---- T 13'	C=120 0.124	Pt 12.12 Pe ---- Pt 1.61	Pt 12.12 Pe 0.352 Pt 11.768	Pn 19.5 Pe (19.5/5.6) ² = 12.12	q=130 X 0.15 = 19.5			
2	2 BL-1	20.75 Q	1.25"	L 13 F ---- T 13	C=120 0.125	Pt 13.73 Pe ---- Pt 1.622	Pt 13.73 Pe 0.502 Pt 13.22	Pn 0.001123Q ^{2/3} q=5.6(13.73) ^{1/2}				
3	3 BL-1	21.94 Q	1.5"	L 13 F ---- T 13	C=120 0.132	Pt 15.35 Pe ---- Pt 1.713	Pt 15.35 Pe 0.646 Pt 14.70	Pn 5.6(15.35) ^{1/2}				
4	4 BL-1	23.13 Q	2"	1 - T F 10 T 29.5	C=120 0.071	Pt 17.06 Pe ---- Pt 2.10	Pt 17.06 Pe 0.448 Pt 16.61	q=5.6(17.06) ^{1/2}				
5	10 BL-1	---- 85.32	4"	L 10 F --- T 10	C=120 0.0028	Pt 19.15 Pe --- Pt 0.03	Pt 19.15 Pe --- Pn	BL-1 Q=85.32				
6	10 BL-2	K equivalent of BL-1; Q=k(P) ^{1/2} > k _{equi} ; Q/(P) ^{1/2} > k _{equi} = 85.32/(19.15) ^{1/2} K _{equi} = 19.49; Q ₂ =k _{equi} (P ₁₀₂) ^{1/2} , Q=19.49(19.18) ^{1/2} > Q ₂ = 85.35 gpm										

Step No.	Nozzle Ident. And Location	Flow In G.P.M.	Pipe Size	Pipe Fittings and Devices	Equiv. Pipe Length	Friction Loss P.S.I/Foot	Pressure Summary	Normal Pressure	Notes	Ref. Step
5	BL1	q 23.2 Q122.6	2"	L 10 1T=10 F ? T ?	1.1	Pt 20 Pe 0.43 Pt ? Pn	Pt Pe Pn			5
6			2.5"	1E=6		Pt ?				6

- What is the G.P.M. at Sprinkler # 5?
- What is the Overall G.P.M. at Sprinkler #5?
- What size is the pipe between points 5 and 6?
- How many fittings are between points 5 and 6?
- What is the Equivalent Pipe Length of the Fitting?
- What is the Total Equivalent Pipe Length of Pipes, Fittings and Devices?
- What is the Pressure Total at Step #6?

Nozzle Ident. And Location	Flow In G.P.M.	Pipe Size	Pipe Fittings and Devices	Equiv. Pipe Length	Friction Loss P.S.I./Foot	Pressure Summary	Normal Pressure	Notes	Ref Step
5 BL1	q 23.2 Q122.6	2"	1T	L 10	1.1	Pt 20	Pt	5	
				F 10		Pe 0.43	Pv		
				T 30		Pf 4.10	Pn		
6		2.5"	1E=6			Pt ?			6

1. What is the G.P.M. at Sprinkler # 5? 23.2
 2. What is the Overall G.P.M. at Sprinkler #5? 122.6
 3. What size is the pipe between points 5 and 6? 2"
 4. How many fittings are between points 5 and 6? 1 T
 5. What is the Equivalent Pipe Length of the Fitting? 10'
 6. What is the Total Equivalent Pipe Length of Pipes, Fittings and Devices?
 7. What is the Pressure Total at Step #6? 24.53 psi

Patterns

- 1) Q should increase upstream
- 2) P should increase upstream
- 3) Note Elevations

Common Problems

- 1) Incomplete submittals
- 2) Inadequate flushing
- 3) Incorrect HW C Factor
- 4) Lack of cut sheets
- 5) Field substitutions

Common Problems

- 6) *Omitted coverage (ie porches in 13R)*
- 7) *No full height cross section*
- 8) *Obstructions*
- 9) *Draft curtains*
- 10) *Loops*

Common Problems

- 11) *Grids*
- 12) *Inracks*
- 13) *Water Curtains*
- 14) *Water flowing up-hill*
- 15) *Unbalanced Flows*

Common Problems

- 16) *Unbalanced pressures*
- 17) *Smaller flows upstream*
- 18) *Negative pressures/flows*
- 19) *Missing demands (water curtains, inracks, corridors)*
- 20) *velocity pressures producing lower results*

Bad Design

- 1) *oversized pipes*
- 2) *inconsistencies between calculations*
- 3) *safety pressures too small*
- 4) *pump vs. no pump*
- 5) *Phony PE stamps*

Sprinkler Requirements Enforcement Issues

Voodoo Hydraulics

- 1. Flow
- 2. Pressure
- 3. Insufficient density/pressure
- 4. Incorrect hydraulic remote area
- 5. Dead Engineer stamps

Sprinkler Requirements Enforcement Issues

NFPA 13D Issues

Densities

- a) .05 gpm/ft²
- b) but not less than minimum flow 13/18gpm

Water Supplies

- a) Pumps in wells
 - (1) Pumps not strong enough
 - (2) No calculations from waterline in well to base of system
 - (3) Duration (well recovery)
- b) Hydraulic calculations for gridded systems

New Issues Antifreeze

- Limit premixed solutions to 38% propylene glycol or 48% glycerin by volume for New and 40% / 50% for Existing
- Other listed premixed solutions
- Annual testing of solutions

New Issues Bedbug Treatment

- Heat damage to fusible elements
- Mechanical damage from covering or removal and replacement
- Impairment procedures

**Does it make
sense???**







Always Read
the
Fine Print



Questions

That was a short example of how hydraulic calculations work, the only way to get proficient in them is to keep doing them.

Hydraulic Calculations for February 2011 Career Development

S_{eq}	N_{ed}	P_{avg}	Q_{avg}	Q_{tot}	C_{fract}	D_{dams}	L_m	F_a	E_{ovl}	L_{To}	$P_{Friction}$	$P_{Friction} \times$	$P_{Friction}$	$P_{Elevation} = P_{Total}$		
		psi	gpm	gpm	or	in	ft	nps		ft	Loss	Loss	on	$L_{Vertical}$	$L_{Vertical}$	
1	1 - 2	12.13	19.5	19.5	120	1.046	2			2	0.124	0.248				12.373
2	2 - 3	12.37	19.7	39.2	120	1.38	2			2	0.119	0.234				12.611
3	3 - 4	12.61	19.9	59.1	120	1.61	2			2	0.12	0.24				12.851
4	4 - 5	12.85	20.1	79.2	120	2.067	3	T, T	10 x 2	23	0.081	1.4	1	0.434		14.688
5	5 - 6	14.89	0	79.2	120	4.026	10			10	0.002	0.024				14.69